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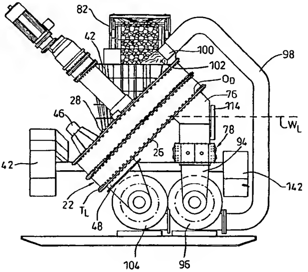

(57) Abrégé/Abstract:
A feed apparatus (10, 90, 160) for introducing particulate material into a fluid conduit includes a particulate material feed member (12) having first and second planar sides (16, 18) spaced apart laterally from one another and a row of material accommodating pockets (14) formed in the feed member (12). Each pocket (14) is in the form of a tube having open opposed ends, one of said open opposed ends being located in the first said planar side (16) of the feed member (12) and the other of said open opposed ends being located in the second planar side (18) of the feed member (12). A fluid inlet port (46) is opposed to said first planar side (16) and a fluid outlet port (48) is opposed to said second planar side (18). The inlet and outlet ports (46, 48) are located in alignment with one another and said row of pockets (14) such that the inlet and outlet ports (46, 48) are in fluid communication with one another via one or more of said pockets (14). An oversize material discharge port is opposed to said second planar side (18) and a mineral reducer (98) is located between the oversize material discharge port and an input into the feed member (12). The feed member (12) is movably mounted in a direction parallel to the planes containing said planar sides (16, 18) to move successive pockets (14) in said row from a material deposit location (M_L), into registry between said inlet and outlet ports (46, 48) to discharge material up to a predetermined size through said fluid outlet port (48), and to said oversize material discharge port to discharge material in excess of said predetermined size, to said mineral reducer (98), through said oversize material discharge port.

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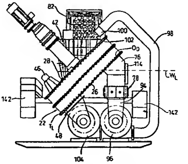

(57) Abstract: A feed apparatus (10, 90, 160) for introducing particulate material into a fluid conduit includes a particulate material feed member (12) having first and second planar sides (16, 18) spaced apart laterally from one another and a row of material accommodating pockets (14) formed in the feed member (12). Each pocket (14) is in the form of a tube having open opposed ends, one of said open opposed ends being located in the first said planar side (16) of the feed member (12) and the other of said open opposed ends being located in the second planar side (18) of the feed member (12). A fluid inlet port (46) is opposed to said first planar side (16) and a fluid outlet port (48) is opposed to said second planar side (18). The inlet and outlet ports (46, 48) are located in alignment with one another and said row of pockets (14) such that the inlet and outlet ports (46, 48) are in fluid communication with one another via one or more of said pockets (14). An oversize material discharge port is opposed to said second planar side (18) and a mineral reducer (98) is located between the oversize material discharge port and an input into the feed member (12). The feed member (12) is movably mounted in a direction parallel to the planes containing said planar sides (16, 18) to move successive pockets (14) in said row from a material deposit location (M_L), into registry between said inlet and outlet ports (46, 48) to discharge material up to a predetermined size through said fluid outlet port (48), and to said oversize material discharge port to discharge material in excess of said predetermined size, to said mineral reducer (98), through said oversize material discharge port.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

FEED APPARATUS

The invention relates to a feed apparatus for introducing particulate material into a fluid conduit to enable the particulate material to be conveyed away by fluid flowing along the conduit.

The invention also relates to fluid conveying apparatus including a feed apparatus as defined above.

In certain mining operations it is often necessary to convey broken mineral away from the location where it is mined to a remote processing location. In open cast mines, the remote processing station may be several kilometres from the location where the mineral is mined. For certain types of mineral such as, for example, tarsand, it is desirable to convey the won mineral in the form of a slurry along a fluid pipeline to the remote processing location. It is also desirable to convey the won mineral in the form of a slurry having a desired specific gravity, i.e. a desired solid to fluid ratio, in order to maximise the rate at which the particulate material is conveyed along the fluid pipeline.

A general aim of the invention is to provide a feed apparatus which enables particulate material, such as won mineral, to be introduced into a fluid pipeline along which conveying fluid is being pumped at a relatively high pressure.

Another general aim of the invention is to introduce particulate material into a fluid pipeline in order to form a slurry having a relatively high specific gravity.

In this way it is possible, with the apparatus of the invention, to convey the particulate material, in the form of a slurry, for greater distances than heretofore achievable, and to maximise the rate at which the particulate material is conveyed along the fluid pipeline.

According to an aspect of the invention there is provided a feed apparatus for introducing particulate material into a fluid conduit, the apparatus including:

a particulate material feed member having first and second planar sides spaced apart laterally from one another and a row of material accommodating pockets formed in the feed member, each pocket being in the form of a tube having open opposed ends, one of said open opposed ends being located in the first said planar side of the feed member and the other of said open opposed ends being located in the second planar side of the feed member;

a fluid inlet port opposed to said first planar side and a fluid outlet port opposed to said second planar side, the inlet and outlet ports being located in alignment with one another and said row of pockets such that the inlet and outlet ports are in fluid communication with one another via one or more of said pockets;

an oversize material discharge port opposed to said second planar side; and

a mineral reducer located between the oversize material discharge port and an input into the feed member,

said feed member being movably mounted in a direction parallel to the planes containing said planar sides to move successive pockets in said row from a material deposit location, into registry between said inlet and outlet ports to discharge material up to a predetermined size through said fluid outlet port, and to said oversize material discharge port to discharge material in excess of said

predetermined size, to said mineral reducer, through said oversize material discharge port.

Embodiments of the invention will now be described, by way of non-limiting examples, with reference to the accompanying drawings in which:

Figure 1 is a diagrammatic perspective view of feed apparatus, according to an embodiment of the invention, shown in use;

Figure 2 is a side view of the feed apparatus shown in Figure 1;

Figure 3 is a plan view of the feed apparatus shown in Figure 2;

Figure 4 is an axial end view of the apparatus shown in Figure 3, as viewed along arrow A;

Figure 5 is a longitudinal sectional view, partly exploded, of the feed apparatus as shown in Figure 2;

Figure 6 is an upper perspective view of the feed apparatus of Figure 2 with the upper casing removed;

Figure 7 is a view similar to Figure 6 with the upper casing and feed disc removed;

Figure 8 is a view similar to Figure 7 including the upper casing but excluding the feed disc;

Figure 9 is a plan view from underneath of the feed apparatus of Figure 2;

Figure 10 is a sectional plan view illustrating the fluid port arrangement of the feed apparatus of Figure 1;

Figure 11 is a flow chart illustrating the passage of particulate material through the feed apparatus shown in Figure 1;

Figure 12 is a plan view of a feed apparatus, according to another embodiment of the invention, shown mounted on a mobile rig;

Figure 13 is an end view of the feed apparatus shown in Figure 12, as viewed along arrow B;

Figure 14 is a side view of the feed apparatus shown in Figure 13;

Figure 15 is a part side view of the feed apparatus shown in Figure 13;

Figure 16 is a plan view of the feed apparatus shown in Figure 15;

Figure 17 is a sectional view along the line VI-VI in Figure 16;

Figure 18 is a part sectional view along long VII-VII in Figure 12;

Figure 19 is a part sectional view showing the inlet and outlet port arrangement of the feed apparatus shown in Figure 12;

Figure 20 is a plan view of a mobile rig incorporating the feed apparatus of Figure 12;

Figure 21 is a side view of the rig shown in Figure 20;

Figure 22 is a diagrammatic representation of the operation flow control utilized in the feed apparatus shown in Figure 12;

Figure 23 is a diagrammatic representation of an oil extraction process according to the invention;

Figure 24 is a flow chart illustrating the passage of particulate material through the feed apparatus shown in Figure 12;

Figure 25 is a plan view of a feed apparatus, according to a yet further embodiment of the invention, shown mounted on a mobile rig;

Figure 26 is an end view of the feed apparatus shown in Figure 25, as viewed along arrow C;

Figure 27 is a side view of the feed apparatus shown in Figure 26;

Figure 28 is a part side view of the feed apparatus shown in Figure 26;

Figure 29 is a plan view of the feed apparatus shown in Figure 28;

Figure 30 is a sectional view along the line VIII-VIII in Figure 29;

Figure 31 is a part sectional view along long IX-IX in Figure 25;

Figure 32 is a sectional view along the line X-X in Figure 29;

Figure 33 is a flow chart illustrating the passage of particulate material through the feed apparatus shown in Figure 12;

A feed apparatus 10 according to a first embodiment of the invention is shown in Figure 1.

The feed apparatus 10 includes a material feed member, preferably in the form of a rotatable wheel or disc 12 (Figure 6). In a typical installation, for use in an open cast mine, the outer diameter of the disc 12 may be in the region of 9 metres. This would enable a throughput of about 5,000 cubic metres/hour to be achieved.

The disc 12 is provided with a row of tube-like pockets 14 arranged in an annulus which is centred upon the axis of rotation of the disc 12. The disc 12, at least in the region of the row of pockets 14, has a pair of planar sides 16,18 which are spaced laterally from one another. Each pocket 14 has opposed open ends; one open end being located in one planar side 16 and the other open end being located in the other planar side 18.

Preferably, the row of pockets 14 is defined by an annular slot in the disc 12 and a series of circumferentially spaced radial vanes 20 which divide the slot into individual pockets 14.

Rotation of the disc 12 about its axis causes the pockets 14 to be moved in succession around the axis of rotation. The planar sides 16,18 are arranged perpendicularly to the axis of rotation so that during rotation of the disc 12, the

planar sides 16,18 are moved in a direction parallel to the planes containing those sides 16,18.

The terminal edges of the vanes 20 are preferably co-planar with the sides 16,18. In accordance with one embodiment of the invention, this enables the open ends of the pockets 14 to be sealed as will be described below. Preferably, as seen in Figure 6, the planar sides 16,18 are raised relative to the remainder of the disc 12 to facilitate sealing.

The disc 12 is rotatably housed within a sleeve-like casing 22 having a cylindrical wall 24. The casing 22 is closed off at its bottom end by a bottom end wall 26 and closed off at its top end by a top end wall 28.

The disc 12 is mounted on a drive shaft 30 which is rotatably mounted within a cylindrical housing 32. The lower end of housing 32 is mounted on the top wall 28, and a drive motor 34 is mounted upon the upper end of the housing 32. The motor 34 serves to rotate the disc 12 within the casing 22, typically at about 10-12 rpm. The motor 34 is preferably adjustable to permit variation of the speed of rotation of the disc 12.

As will be described in more detail below the apparatus 10, around the periphery of the casing 22, includes a succession of operating locations to which each pocket 14 is moved in succession. The operating locations preferably include:

(i) a material loading location M_L whereat material to be transferred is deposited and loaded into the pockets 14;

(ii) a fluid loading location F_L whereat pockets 14 containing material to be transferred are filled with water (this ensures that the material to be transferred is already mixed with water prior to introduction into the fluid conveying pipeline and also ensures that the pockets 14 are filled with material and fluid (i.e. do not contain air pockets) prior to introduction into the pipeline);

(iii) a material transfer location T_L whereat material contained in a pocket 14 is transferred into the fluid conveying pipeline;

(iv) a fluid draining location F_D whereat water contained in the pockets 14 is allowed to drain out of the pockets 14; and

(v) an oversize discharge location O_D whereat oversize material contained in the pockets 14 is allowed to discharge out of the pockets 14.

The disc 12 is preferably continuously rotated (anti-clockwise as seen in Figure 4) in order to move each pocket 14 in succession through each of the operating locations (i) to (v).

As seen in Figures 1 and 2 the casing 22 is preferably inclined at approximately an angle 45° to the horizontal so that, in use, the casing has an upper portion 22_U and a lower portion 22_ℓ.

A cowling 36 is attached to the top wall 28 in the region of the lower portion of the casing 22 so as to define an open topped water tank 38.

The top wall 28 of the casing 22 is provided with an arcuate slot 40 which extends from the upper portion of the casing 22 and downwards into the lowermost region of the casing. The slot 40 overlies the annulus of pockets 14 and so provides access into the pockets 14.

The arcuate slot 40 is bounded by an upwardly projecting flange wall 42 which extends from the top wall 28. The flange wall 42 and top wall 28 combine to form a hopper region 44 into which material to be transferred into the fluid pipeline is deposited. The deposited material falls into the exposed pockets 14 located within the hopper region 44.

In use, the water tank 38 is filled with water up to a level indicated as W_L. The lower portion 40_{ℓ} of slot 40, in use, is located below the water level W_L.

Accordingly, as the disc 12 rotates, pockets 14 filled with material to be transferred are immersed into the water tank 38 before reaching the material transfer location T_L.

Lower portion 40_{ℓ} of the slot 40 thereby defines the fluid loading location F_L.

At the material transfer location T_L, there is provided a fluid inlet port 46 and a fluid outlet port 48.

In the first embodiment, the fluid inlet port 46 is connected to an inlet pipeline (not shown) which conveys clean conveying fluid (usually water) to apparatus 10 and the fluid outlet port 48 is connected to an outlet pipeline (not shown)

which conveys away a slurry comprising the conveying fluid mixed with the material transferred from pockets 14.

Each port 46,48 includes a pipe section 50 which at one end is sealingly secured to a rigid pressure plate 52. The opposite end of the pipe section 50 is adapted for connection to the pipeline.

The pressure plate 52 carries a sealing plate or pad 54 formed of a low friction material which is resiliently biased into sliding sealing contact with the planar sides 16,18 and terminal edges of the vanes 20. The biasing force on the pressure plate 52 is preferably produced by two or more compression springs 56 interposed between the pressure plate 52 and a housing plate 58 secured to the top or bottom wall of the casing 22. The pressure plate 52 and sealing plate 54 contain a common aperture 60 which provides fluid communication between the pipe section 50 and pockets 14.

As indicated above, each planar side 16,18 is defined by an annulus raised relative to the remainder of the disc 12 and so, as indicated in Figure 6, each planar side 16,18 defines continuous inner and outer sealing rings 62,64 respectively which continuously bound the circumference of the annulus of pockets 14.

The size of each sealing plate 54 and aperture 60 are chosen such that the plate 54 overlies, and sealingly engages, both the inner and outer sealing rings 62,64 during rotation of the disc 12. This ensures that fluid within the pipelines connected to the inlet and outlet ports is sealingly retained between the inlet and outlet ports during rotation of the disc 12.

Preferably the sealing plate 54 is formed from a suitable plastics material such as a glass filled ultra high molecular weight polyethylene.

As seen in Figures 6 and 10, the vanes 20 are preferably inclined relative to the direction of movement of the disc 12.

Inclination of the vanes 20 is preferably adopted in order to avoid problems with jamming caused by a vane 20 and the top wall 28 in the vicinity of the end wall of the slot 40 attempting to grip and shear lumps of material protruding out of the top of a pocket as it is moved under the top wall 28.

By inclining the vanes 20 such that the upper edge of the vane 20 trails behind the lower edge of the vane (in the direction of rotation), lumps of material protruding out of a pocket 14 are encouraged to roll over the edge of the vane and into the next pocket. The degree of angle of inclination of the vane 20 is chosen bearing this required function in mind.

Preferably, in the first embodiment, each aperture 60 is closed off by a sizing grid 66. The sizing grid 66 has a series of apertures or slots which determine the maximum size of lump of material which is able to be conveyed out of the pockets 14 in registry with ports 46,48. This ensures that only material up to a desired maximum lump size is conveyed away and along the fluid conveying pipeline.

Each sizing grid 66 preferably has a side face 68 which is co-planar with the sealing face of the sealing plate 54.

Accordingly, the vane edges slidingly move over the side face 68 and act as scraper blades to clear debris therefrom so as to keep the sizing grids 66 clear.

It will be appreciated that the fluid seal between the disc 12 and ports 46,48 is achieved by a sliding sealing contact between planar sides 16,18 and plates 54. A reliable seal can, therefore, be achieved, even at relatively high fluid pressures.

In use, it is envisaged that the pipe section 50 of the inlet port 46 is connected to a pipeline communicating with a high-pressure fluid inlet pump such as a multi-stage turbine pump. Typically such a pump is capable of generating fluid pressure in the region of 20-25 bar.

It will be appreciated therefore that when a pocket 14 is brought into registry with the inlet and outlet ports 46,48, the pocket 14 is in fluid communication with a flow of high-pressure fluid which serves to completely flush undersize material out of the pocket 14 and through the sizing grid 66 associated with the outlet port 48. The high-pressure fluid flow forces the undersize material through the grid 66, and so enables sticky material, such as tarsand, to be sized without clogging of the grid 66.

After a pocket 14 exits registry with the inlet and outlet ports 46,48, it will be appreciated that it will be filled with conveying fluid and oversized material.

In the first embodiment the bottom wall 26 is provided (Figure 7) with a series of apertures 70 arranged along an arcuate path underlying the annulus of

pocket 14. The arcuate path of apertures collectively forms a drainage screen along the bottom of pockets 14 as they move upwardly out of the water tank 38. The size of apertures 70 is chosen to ensure that water can drain through the bottom wall 26 whilst retaining oversized material within the pockets 14.

On the underside of the bottom wall 26 a closed channel member 72 is provided in order to define a fluid return channel to the water tank 38 for water draining through apertures 70.

The water tank 38 is filled by water draining from the pockets 14 as the pockets move out of registry with the inlet and outlet ports 46,48. The water initially enters the interior of the casing 22 and then flows between the disc 12 and inner walls of the casing 22, into the water tank 38, through the lower portion of slot 40. In order to prevent the water tank 38 from overflowing, and maintain the water level at W_L, an overflow outlet 74 is provided.

After the pockets 14 have moved over the drainage screen, they move to a discharge chute 76 formed in the bottom wall 26. The oversize material is discharged from chute 76, preferably into a crusher (or mineral reducer) 78, such as a twin roll crusher. The crushed material is preferably reduced to a size capable of being passed through the sizing grid 66.

Accordingly, the crushed material is preferably conveyed away by a takeaway conveyor 80 to be deposited on a feed conveyor 82 which is feeding material to be transferred into the pipeline via the feed apparatus 10. Accordingly, the crushed oversize material is conveniently transferred away along the fluid conveyor.

A flow chart illustrating the passage of particulate material through the feed apparatus 10 is shown in Figure 11.

It will be appreciated that, since the feed apparatus 10 is capable of feeding material into a high-pressure pipeline, it is possible to convey the slurry a longer distance than if the slurry itself were being pumped.

In the above example, apertures 60 are of a size and shape similar to the cross-sectional size and shape of a single pocket 14 such that, at any point in time, fluid communication between the inlet and outlet ports 46,48 is via a single pocket 14.

It is envisaged that the shape and size of each aperture 60 may be increased such that the inlet and outlet ports 46,48 communicate via two or more pockets 14 at any point in time. By increasing the number of pockets 14 which provide fluid communication between the ports 46,48, it is possible to increase the volume ratio of solids to conveying fluid exiting via the outlet port 48 without increasing the velocity of rotation of the disc 12. It also means that, for a given volume of throughput of solid material, a smaller diameter of disc 12 may be provided.

Preferably, the size and shape of each aperture 60, and the sizing grid 66, is chosen such that the cross-sectional area of open space within the grid 66 is greater than the cross-sectional area of a single pocket 14.

In the above example, a high-pressure inlet pump is utilized to pump water along the inlet pipeline for feeding water under pressure through the inlet port 46.

It is envisaged that either in addition to the inlet pump, or as an alternative to the inlet pump, an outlet pump (preferably in the form of a vaned centrifugal pump) is provided in fluid communication with the outlet port 48 for drawing the solid/water slurry from the outlet port 48.

By having a combination of an inlet pump and an outlet pump it is possible to create a greater flow of water through the feed apparatus 10 whilst at the same time reducing the fluid pressure inbetween the inlet and outlet ports 46,48. The reduction in fluid pressure facilitates sealing between the disc 12 and inlet/outlet ports 46,48.

In the first embodiment, as shown in Figure 10, the pressure plate 52 and sealing plate 54 are biased by means of springs 56. It is envisaged that, as an alternative to springs 56, fluid hydraulic means may be provided for applying a biasing force onto the pressure plate 52.

A feed apparatus 90 according to a second embodiment of the invention is shown in Figure 12. Parts similar to those described with reference to Figures 1-11 are designated with the same reference numerals.

The feed apparatus 90 is particularly suitable for use in the excavation and discharge of tarsand from an open cast mine, and differs in several respects to the first embodiment described with reference to Figures 1-11.

In one respect, the open topped water tank 38 defined by the cowling 36 is dispensed with and, instead, the casing 22 is arranged to fully envelope the disc 12, save for the slot 40 formed in the top wall 28, and an opening 92 formed in the bottom wall 26 which communicates with the discharge chute 76.

Also fluid draining location F_D is dispensed with.

The discharge chute 76 extends between the bottom wall 26 of the casing 22 and the top of the crusher 78 so as to define an enclosed fluid conduit between the casing 22 and the interior of the crusher 78. A closed sump 94 is provided beneath the crusher 78 to receive the crushed material and water.

Accordingly, the interior of the casing 22, chute 76, interior of the crusher 78 and closed sump 94 are all in fluid communication and, in combination, define a closed, fluid tight, container.

In use therefore, as disc 12 rotates, oversized material and water are conveyed by pockets 14 to the oversize discharge location O_D from which oversized material and water are discharged into the crusher 78.

In a particular embodiment of the invention, end portions of the slot 40 and opening 92 overlap to provide fluid communication between the hopper region 44 and the discharge location O_D so as to enable material/water contained in the casing 22 to pass directly into the discharge chute 76.

In use, the water level W_L within the casing 22 is located in the vicinity of the lower region of opening 92 and the vicinity of the upper region of slot 40. In view of this, the material deposit location M_L coincides with the fluid loading location F_L. This is advantageous in that the tarsand being deposited into the hopper region 44 is hydrated and mixed with water as it falls into the pockets 14. This action assists in the breaking down of lumps and settlement of the solid material into the pockets 14.

The sump 94 of the crusher 78 is in fluid communication with a pump 96 which pumps the water/crushed material slurry mixture from the sump 94 and along a return conduit 98.

The return conduit 98 has a discharge nozzle 100 which discharges a jet 102 of the water/crushed material slurry in a generally downwards direction, into the hopper region 44 defined by flange wall 42, and towards the exposed pockets 14 of disc 12.

It is advantageous to also direct the jet of slurry into the airborne stream of solid material as it is being discharged from the delivery conveyor 101 in order to wet the material and promote break down of lumps in the solid material prior to it falling into the material/fluid loading location M_L/F_L. The downwardly directed jet also agitates solid material which has been deposited within pockets 14 at the material/fluid loading location M_L/F_L, and so helps to further promote break down of the solid material and ensure efficient filling of the pockets 14 with solid material before being conveyed to the material transfer location T_L.

An outlet pump 104 (preferably in the form of a vaned centrifugal pump) is located adjacent to the outlet port 48 for drawing the slurry from port 48. Pump 104 has an output port 206 which, in use, is connected to an outlet pipeline 108 (Figure 22).

As schematically illustrated in Figure 22, conveying fluid (usually water) is pumped along a delivery pipeline 110 to the inlet port 46.

For a tarsand application, the diameter of the pipelines 108,110, and conduit 98, will typically be about 24 inches. The pumping capacitance of pumps 96,104 are preferably the same.

In use, solid material is deposited into the apparatus at a feed rate V_S, the delivery pipeline 110 delivers conveying fluid at a rate of V_I and the pump 104 extracts the slurry S_F at a rate of V_O. It will be appreciated that if the combined rates V_S and V_I equal the extraction rate of V_O, the level of water within the casing 22 will remain constant. However, in operation in an open cast mine, it is expected that the feed rate V_S of the solid material will not be constant and so the level of water within the casing 22 can be expected to vary. Accordingly, an operational control is required in order to maintain the water level at a desired optimal level W_L.

This is preferably achieved in the embodiment illustrated in Figures 12-24 by controlling delivery pump 112 and outlet pump 104 to maintain rates V_I and V_O respectively constant and varying the rate of delivery V_S of the solid material by monitoring the water level W_L in the chute 76. In this respect the chute 76 is preferably provided with a vertical pipe 114 which, at its lower end,

is in fluid communication with the interior of the chute 76. The pipe 114 extends above and below the level W_L and includes a sensor for sensing the level of water within the pipe 114. The sensor may be a pressure sensor or may be an optical sensor, which detects the surface of the water in the pipe 114. The sensor is arranged to send an electrical signal to a control which functions to vary the delivery rate V_S of the solid material. Accordingly, if the water level rises above a desired level W_L, the control acts to reduce the rate of delivery V_S. This will cause the water level to fall back toward the level W_L and, when it does so, the control acts to increase the rate of delivery V_S in order to ensure that the level does not fall below level W_L.

In other embodiments, the speed of rotation of the disc 12 may also be varied in order to vary the solid to water ratio in each pocket.

In tarsand mining, it is desirable to convey along the outlet pipeline slurry of a desired specific gravity (about 1.6) i.e. a desired solid to water ratio. This desirable ratio may be achieved by the appropriate selection of the V_S and V_I rates. For example the higher the V_S rate in proportion to the V_I rate the higher the specific gravity of the slurry S_F.

It is appreciated that the maximum specific gravity achievable may be limited by the lump size of the solids within the slurry S_F for a given rate V_O bearing in mind that the solids within the slurry S_F need to remain in suspension whilst being pumped along the outlet pipeline 108 by pump 104.

As indicated above, reduction in lump size of the solid material can occur whilst the solid material is being deposited into the hopper region 44 due to the

action of the solid material being immersed in water and being exposed to the action of the jet 102 of slurry discharged by nozzle 100.

It is, however, envisaged that further reduction in lump size, and a greater consistency of reduced lump size throughout the slurry S_F, may be achieved by diverting a desired amount of the deposited solid material into the chute 76 thereby exposing this desired amount of deposited material to the action of the crusher 78 and pump 96.

A proportion of the slurry returned to the hopper region 44 will be recirculated back to the crusher 78, and may be broken down further. Another portion of the slurry being discharged by nozzle 100 will mix with the solid material being deposited into the hopper region 44 by conveyor 82 and so the overall lump size of the solid mixture being carried in the pockets 14 to the material transfer location T_L will be smaller than if all the material being deposited by the conveyor 82 were delivered directly to the transfer location T_L.

In an extreme example, it is envisaged that all the material being delivered by the conveyor 82 is directed to the crusher 78 via the chute 76. This means that all the delivered material is thoroughly mixed with water and reduced in size by being exposed to the action of the crusher 78 and pump 96 before being deposited in a lower region of the hopper 44 for transfer to the transfer location T_L by the disc 12.

A flow chart illustrating the passage of particulate material through the feed apparatus 80 is shown in Figure 24.

Since the internal volume of the fluid container defined by the casing 22, chute 76, crusher 78 and sump 94 is fixed, it will be appreciated that the relative volumes of solids to water within this container will be greater if a greater amount of solids is diverted to the chute 76. This in turn provides a greater density of solids within the water present in the fluid container i.e. provides a slurry having a greater specific gravity.

It is envisaged that the desired amount of material which is diverted to the chute 76 for recirculation may be controlled by the amount by which the opening 92 circumferentially overlaps with the slot 40, i.e. the greater the overlap, the higher the proportion of material which will be diverted to the crusher 78. In order to provide the facility for the diverted amount of solid material to be varied during operation of the apparatus, it is envisaged that the size of opening 92 may be adjustable to vary the degree of overlap with slot 40. This may be conveniently achieved by the provision of a slidable plate operably moved by a drive means such as a hydraulic ram to open/close the opening 92 and thereby increase or decrease the amount of overlap between the opening 92 and slot 40.

The feed apparatus 90 also differs from the feed apparatus described with reference to Figures 1-11 in that the inlet and outlet ports 46,48 are not sealingly engaged with the disc 12. This is particularly advantageous as it obviates the need to provide seals and so also obviates wear and maintenance problems associated with seals.

This is achieved by locating pump 104 in close proximity to the outlet port 48 to create suction at port 48 and forming the inlet port 46 into a jet nozzle 116 which acts to direct a high velocity jet of water toward the outlet port 48.

Accordingly, the jet nozzle 116 discharges at a high velocity a jet of water of predetermined shape into each pocket 14 as the pockets 14 sweep past the nozzle 116. The momentum of the high velocity jet throws the conveying water towards the outlet port 48 whereat it is rapidly conveyed away by the pump 104.

Preferably the nozzle 116 is in the form of a slot 118 which extends radially relative to the disc 12. The nozzle 116 thereby creates a high velocity jet of water of sheet-like or blade-like form, which sweeps across each pocket 14 as it passes by the nozzle 116. Preferably the cross-sectional area of slot 118 is the same as the cross-sectional area of the inlet conduit 46a of port 46. This is preferred as it provides an increase in velocity without a change of pressure. Such a nozzle 116 positively projects water into the pocket 14 to dislodge and drive solid material toward the outlet port 48. The high velocity of the jet helps to break down further the lumps of material, and also helps to maintain the vanes 20 and internal surfaces of pockets 14 clean.

The nozzle slot 118 is formed in a plate 120 which is located in close proximity to the opposed side of the disc 12. The gap between the plate 120 and disc 12 is preferably chosen to be relatively small. In view of this, and the high velocity at which water is thrown into the pockets 14 toward the outlet port 48, there is little seepage of water between the inlet port 46 and disc 12.

Since pump 104 is normally operating to create suction at outlet port 48, any flow of water between the disc 12 and the outlet port 48 is toward the outlet port 48 rather than in the opposite direction.

Another difference with respect of the feed apparatus 10 described with reference to Figures 1-11 is that it is envisaged that the feed apparatus is operated at an elevated temperature. This is preferably achieved in this embodiment by heating water flowing into the inlet port 46 and, if necessary, heating the casing 22. This is particularly useful when the apparatus is being used to introduce tarsand into the discharge pipeline. The tar content of the tarsand can be very sticky and so can easily cause blockages. To avoid this it is envisaged that the inlet water flowing into the inlet port 46 is sufficiently hot, say 40-70°C, to render the tar content fluid. An added benefit of using the return conduit 98 is that heated water is discharged by the nozzle 100 and so preheats the material being deposited by the conveyor 82 before mixing with the water contained in casing 22.

A further advantage of operating the feed apparatus at an elevated temperature is that it enables the tar to be separated from the sand in the vicinity where the tarsand is being mined so that the sand can be dumped in the mine and only the fluid tar need be pumped out of the mine.

A system for separating tar from sand using the feed apparatus 90 according to this embodiment of the invention is diagrammatically illustrated in Figure 23. In the system 122 illustrated in Figure 23, the tarsand T_S is introduced into the outlet pipeline 108 via feed apparatus 90 operating at an elevated temperature,

say about 60°C. At this temperature, the tar will be fluid and will be conveyed along outlet pipeline 108 in a fluid condition together with the sand.

The pipeline 108 is connected to a separating station 124 whereat the sand and fluid tar are separated from one another and from the conveying water. Conveniently the separating station 124 is in the form of a cyclonic separator 126 which has an outlet 128 for the fluid tar, an outlet 130 for the sand and an outlet 132 for the conveying water. The fluid tar is preferably discharged into a pipeline 134 which conveys the tar to a processing plant remote from the mine.

The conveying water is conveniently fed into a reservoir 136 from which water is drawn by pump 112 and fed along the delivery pipeline 110 back to the feed apparatus 90. Conveniently the water conveyed by pipeline 110 is heated by electrical heaters 138.

In Figures 20 and 21 there is illustrated an example of a mobile rig 140 incorporating a feed apparatus 90 according to this embodiment of the invention. The mobile rig 140 is suitable for use in open cast mining operations to receive won material, such as tarsand, from a digger (not shown).

The rig 140 includes an elongate chassis 142 having floor engaging supports 144 in the form of skids, which are normally seated upon the ground during operation of the rig.

A feeder hopper 146 is mounted at one end of the chassis 142 and includes a plate feeder 148 which is arranged to feed material deposited into the hopper 146 to a primary mineral breaker 150. Preferably the primary mineral breaker

is a twin roll breaker and, for a tarsand application, is arranged to break the delivered tarsand down to a maximum size of 16 inches.

The delivery conveyor 82 for delivering the tarsand to the feed apparatus 90 is mounted on the chassis 142 so as to extend from beneath the primary breaker 150 and along the chassis 142 to the feed apparatus 90.

Preferably the sensor for controlling the water level W_L in the casing 22 is operatively connected to a control for controlling the speed of the plate feeder 148. The primary breaker 150 and the conveyor 82 are operated at a constant speed. Accordingly the rate of delivery of the tarsand to the feed apparatus 90 is controlled by varying the speed of the plate conveyor 148 only.

A drive unit preferably in the form of a slewable continuous track assembly 152 is mounted beneath the chassis 142. The track assembly 152 includes a pair of powered continuous tracks 154 and is preferably mounted to the chassis 142 via a turntable 156 so as to enable the pair of tracks 154 to be slewed through 360°. The turntable 156 is preferably mounted to the chassis 142 via extensible hydraulic rams 158 which enable the turntable to be moved downwardly away from the chassis 142 in order to lift the skids free of the ground and so enable the drive unit to transport the rig to a different location. When at the desired location, the rams 158 are retracted to seat the chassis 142 onto the ground via the skids.

The rams 158 are also retractable in order to lift the tracks 152 clear of the ground whilst the chassis 142 is seated upon its skids. This enables the tracks to be run whilst clear of the ground for maintenance purposes and also enables

the tracks to be slewed to any angular direction before being seated upon the ground and so enable the rig to be moved from a standing start in any selected angular direction. This can be an important safety aspect should it be necessary to move the rig away from a hazard such as collapsed/unsafe ground.

Typically the mobile rig 140 is arranged to handle a throughput of tarsand of about 5,000 tons per hour. For such an arrangement, pumps 96,104 will typically be 2,000 kW pumps capable of pumping fluid along respective pipelines at about 3 to 5 metres/min.

Pumps 96,104 are preferably vaned centrifugal pumps. Such pumps not only pump the fluid, but act as efficient mixers. They therefore help to break down lumps contained in the slurry and water/crushed material slurry mixture further.

A feed apparatus 160 according to a third embodiment of the invention is illustrated in Figures 25-35. The feed apparatus 160 is similar to the second embodiment described with reference to Figures 12-24. Parts similar to those described with reference to Figures 12-24 are designated with the same reference numerals.

The main difference between the feed apparatus 90 according to the second embodiment of the invention, and the feed apparatus 160 according to the third embodiment of the invention, is that, in the third embodiment, the return conduit 98 is connected to the inlet port 46, and the delivery pipeline 110 is arranged to deliver conveying fluid (usually water) to the hopper region 44. This arrangement helps to increase the achievable specific gravity of the slurry

being pumped through the outlet port 48 since the slurry contained within each pocket 14 is discharged by a jet of a slurry being pumped through the inlet port 46 as opposed to a jet of clean conveying fluid.

In the third embodiment as shown in Figure 25, the material deposit location M_L coincides with the fluid loading location F_L by arranging the delivery pipeline 110 to deliver conveying fluid (usually water) to the hopper region 44. This is advantageous in that solid material being deposited into the hopper region is hydrated and mixed with water as it falls into the pockets 14.

As in the feed apparatus 90 described with reference to Figures 12-24, this action assists in breaking down of lumps and settlement of the solid material into the pockets 14.

The conveying fluid is preferably heated before being delivered to the hopper region 44. This is useful when the feed apparatus 160 is being used to introduce tarsand into the discharge pipeline. It is envisaged that the water delivered to the hopper region 44 is sufficiently hot, say 40-70°C, to render the tar content fluid.

As in the embodiment described with reference to Figures 12-24, operating the apparatus at an elevated temperature enables the tar to be separated from the sand in the vicinity where the tarsand is being mined so that the sand can be dumped in the mine and only the fluid tar need be pumped out of the mine.

The delivery pipeline 110 may include a dicharge nozzle 162 which discharges a jet 164 of conveying fluid in a generally downward direction, into the hopper region 44, and towards the exposed pockets 14 of disc 12.

It may also be advantageous to direct the jet of conveying fluid into the airborne stream of solid material as it is being discharged from the delivery conveyor 82 in order to wet the material and promote break down of lumps in the solid material prior to it falling into the material/fluid loading location M_L/F_L. The downwardly directed jet may also agitate solid material which has been deposited within pockets 14 at the material/fluid loading location M_L/F_L, and so may help to further promote break down of the solid material and ensure efficient filling of the pockets 14 with solid material being conveyed to the material transfer location T_L.

In this embodiment, the return conduit 98 is arranged to pump the water/crushed material slurry mixture from the sump 94 to the inlet port 46.

The water/crushed material slurry mixture flushes material up to a desired lump size from the pockets 14 in registry with ports 46,48, and into the fluid conveying pipeline 108.

This is advantageous in that using the recirculated material to flush the pockets 14 assists in maintaining the viscosity of the slurry S_F, and increasing the efficiency of the feeding apparatus 160. It therefore assists in obtaining a slurry having a greater specific gravity.

A flow chart illustrating the passage of particulate material through the feed apparatus 160 is shown in Figure 33.

CLAIMS

1. A feed apparatus for introducing particulate material into a fluid conduit, the apparatus including:

a particulate material feed member having first and second planar sides spaced apart laterally from one another and a row of material accommodating pockets formed in the feed member, each pocket being in the form of a tube having open opposed ends, one of said open opposed ends being located in the first said planar side of the feed member and the other of said open opposed ends being located in the second planar side of the feed member;

a fluid inlet port opposed to said first planar side and a fluid outlet port opposed to said second planar side, the inlet and outlet ports being located in alignment with one another and said row of pockets such that the inlet and outlet ports are in fluid communication with one another via one or more of said pockets;

an oversize material discharge port opposed to said second planar side; and

a mineral reducer located between the oversize material discharge port and an input into the feed member,

said feed member being movably mounted in a direction parallel to the planes containing said planar sides to move successive pockets in said row from a material deposit location, into registry between said inlet and outlet ports to discharge material up to a predetermined size through said fluid outlet port, and to said oversize material discharge port to discharge material in excess of said predetermined size, to said mineral reducer, through said oversize material discharge port.

2. A feed apparatus according to Claim 1 wherein the feed member is in the form of a disc which is rotatable about a central axis and said row of pockets is in the form of an annulus centred on said central axis.

3. A feed apparatus according to Claim 2 wherein said central axis is inclined, the disc being housed in a closed casing which is open only at an open-topped hopper communicating with said material deposit location.

4. A feed apparatus according to Claim 3 wherein said central axis inclined at an angle of 45° to the horizontal.

5. A feed apparatus according to Claim 2 or Claim 3 wherein said material deposit location partially overlaps with said oversize material discharge port to permit a portion of material being deposited at said material deposit location to discharge through said oversize material discharge port.

6. A feed apparatus according to any one of Claims 2 to 5 wherein opposed sides of each pocket are defined by radially extending vanes.

7. A feed apparatus according to Claim 6 wherein the vanes are inclined relative to said direction of movement of the feed member.

8. A feed apparatus according to any preceding claim including a fluid feed location for filling each pocket with fluid prior to the pocket moving into registry between said inlet and outlet ports.

9. A feed apparatus according to Claim 8 wherein said fluid feed location is positioned between said material deposit location and said inlet and outlet ports.

10. A feed apparatus according to Claim 8 wherein said fluid feed location coincides with said material deposit location.

11. A feed apparatus according to any one of Claims 8 to 10 wherein said fluid is heated to a temperature in the range of 40-70°C.

12. A feed apparatus according to any preceding claim wherein the outlet port is closed by a sizing grid which serves to retain said material in excess of said predetermined size within a pocket in registry with said inlet and outlet ports.

13. A feed apparatus according to any preceding claim wherein said oversize material discharge port defines a fluid outlet for excess fluid.

14. A feed apparatus according to Claim 13 further including a pump and return conduit between said mineral reducer and particulate material feed member to pump crushed material and fluid to said material deposit location.

15. A feed apparatus according to Claim 14 wherein said return conduit includes a discharge nozzle which discharges a jet of crushed material and fluid into an airborne stream of particulate material being delivered to said material deposit location.

16. A feed apparatus according to Claim 13 further including a pump and return conduit between said mineral reducer and particulate material feed member to pump crushed material and fluid to said fluid inlet port.

17. A feed apparatus according to any one of Claims 14 to 16 wherein said pump is a vaned centrifugal pump.

18. A feed apparatus according to any preceding claim wherein an outlet pump is located_in close proximity to said fluid outlet port to create suction at said fluid outlet port, and said fluid inlet port is formed into a jet nozzle.

19. A feed apparatus according to Claim 18, when dependent on Claim 2, wherein said jet nozzle is in the form of a slot which extends radially relative to said disc.

20. A feed apparatus according to Claim 19 wherein the cross-sectional area of said slot is the same as the cross-sectional area of an inlet conduit of said fluid inlet port.

21. A feed apparatus according to any one of Claims 18 to 20 wherein said outlet pump is a vaned centrifugal pump.

22. A process for forming a slurry for conveying particulate material along a pipeline, the processing including mixing said particulate material with a conveying fluid using a feed apparatus according to any preceding claim to form said slurry and subsequently pumping said slurry along said pipeline.

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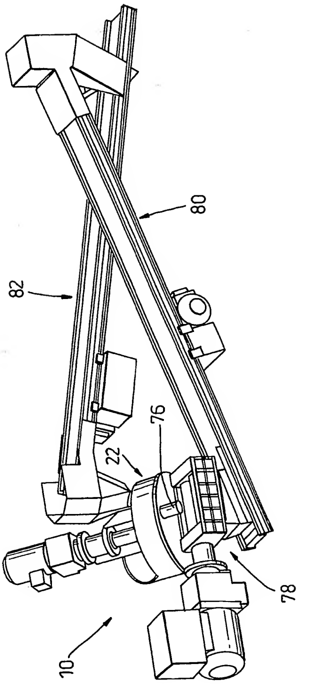

Fig. 1

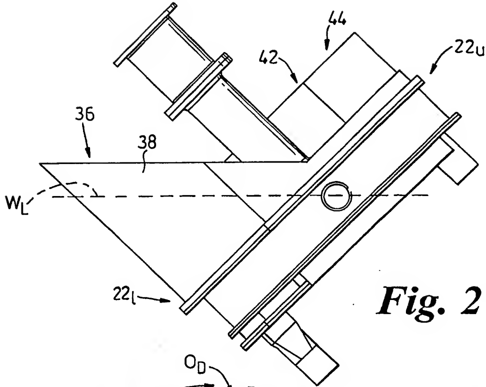

Fig. 2

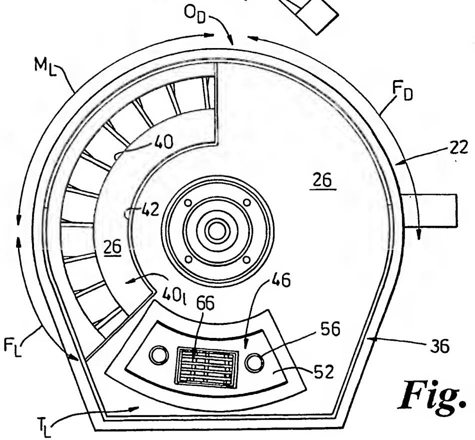

Fig. 4

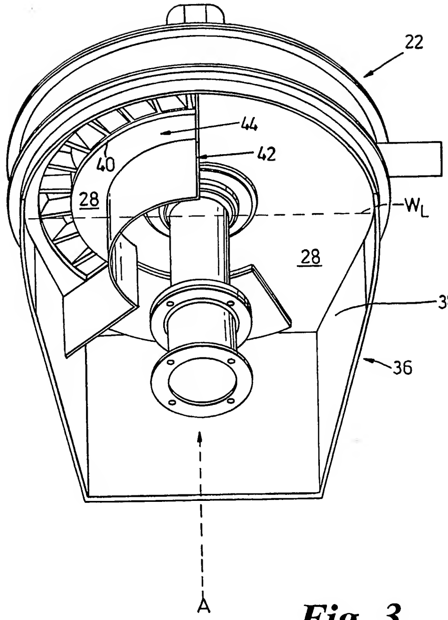

Fig. 3

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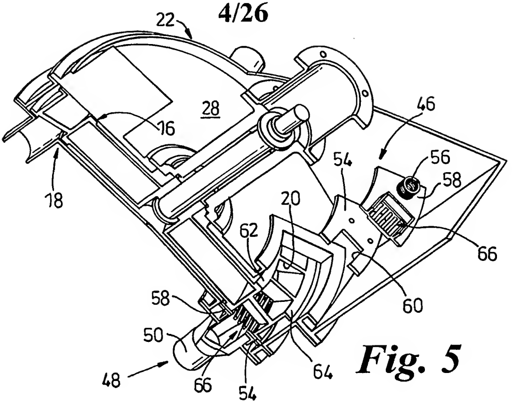

Fig. 5

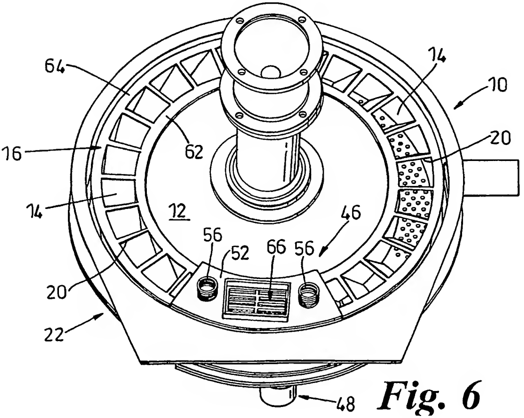

Fig. 6

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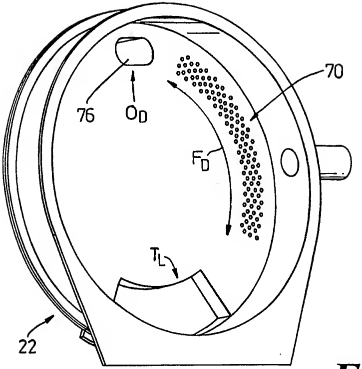

Fig. 7

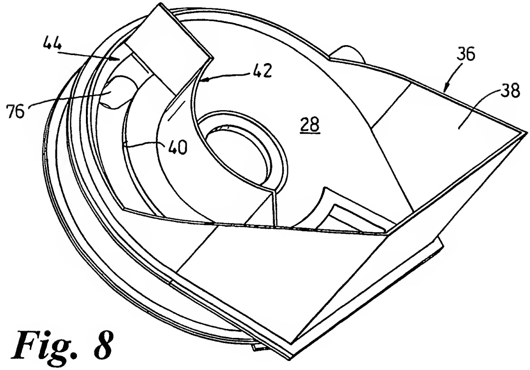

Fig. 8

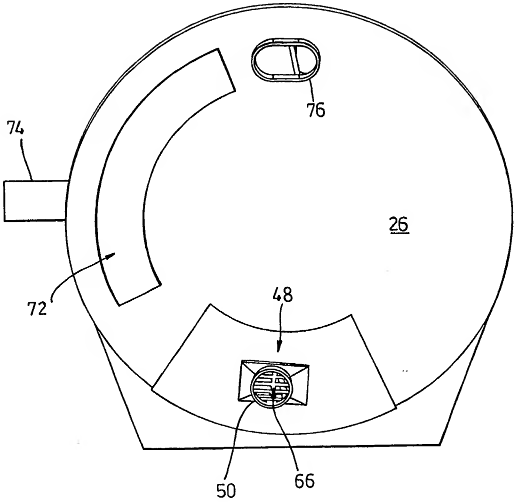

Fig. 9

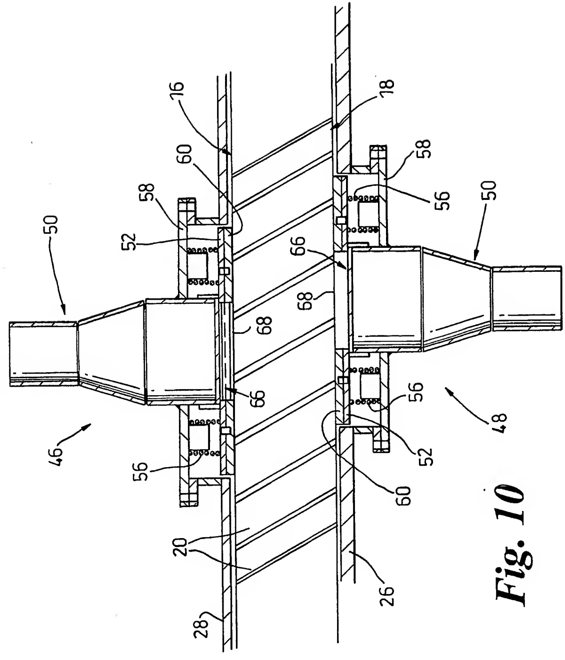

Fig. 10

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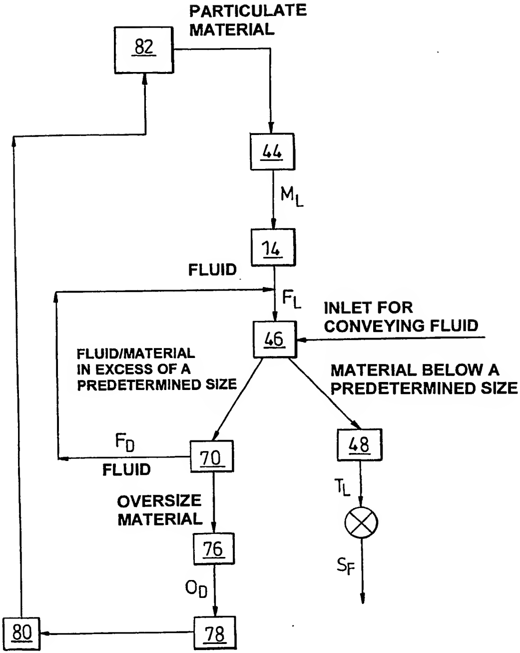
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82
44
M_L
14
FLUID
F_L
INLET FOR CONVEYING FLUID
46
FLUID/MATERIAL IN EXCESS OF A PREDETERMINED SIZE
MATERIAL BELOW A PREDETERMINED SIZE
F_D
70
FLUID
48
T_L
OVERSIZE MATERIAL
76
S_F
O_D
80
78

Fig. 11

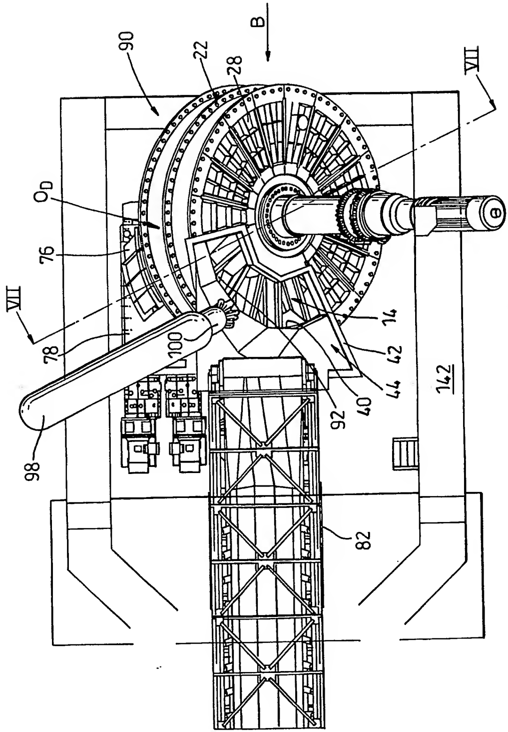

Fig. 12

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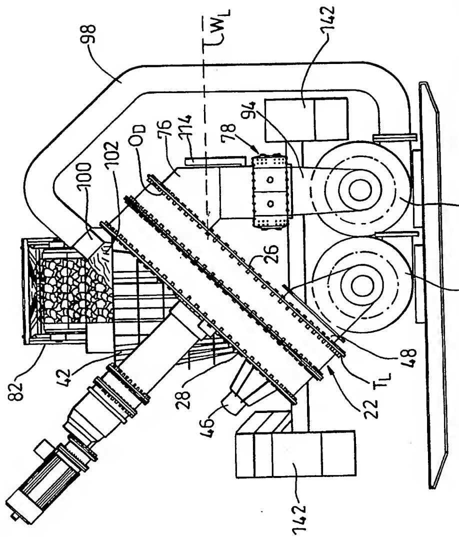

Fig. 13

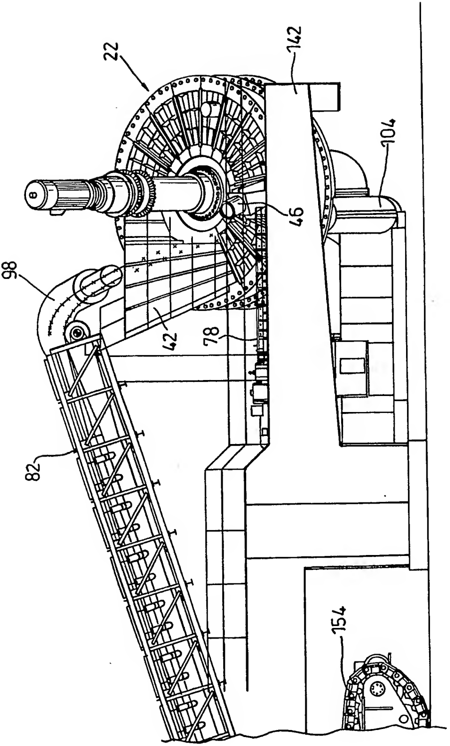

Fig. 14

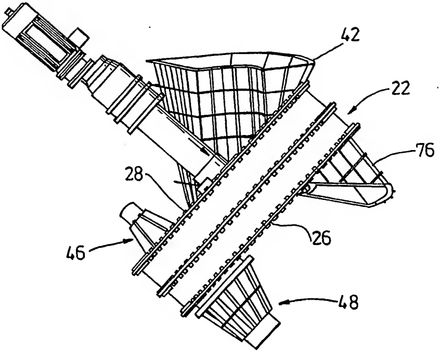

Fig. 15

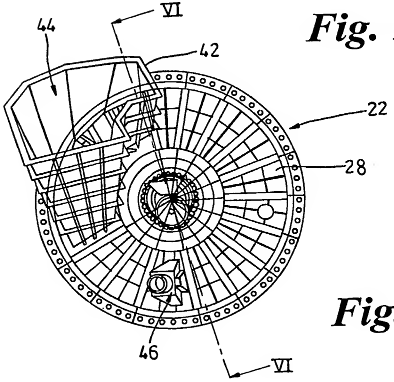

Fig. 16

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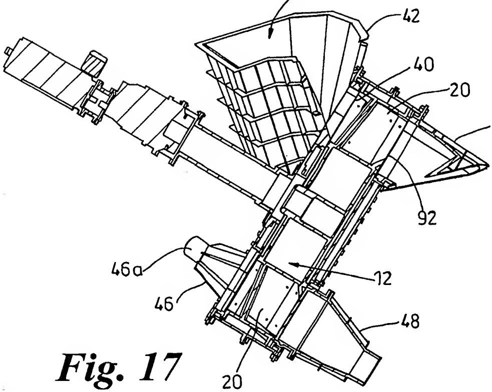

Fig. 17

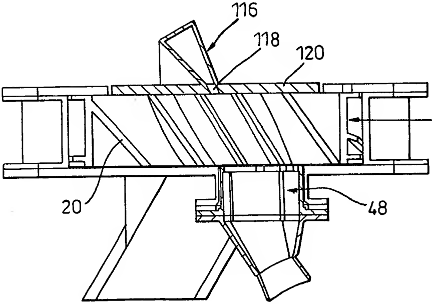

Fig. 19

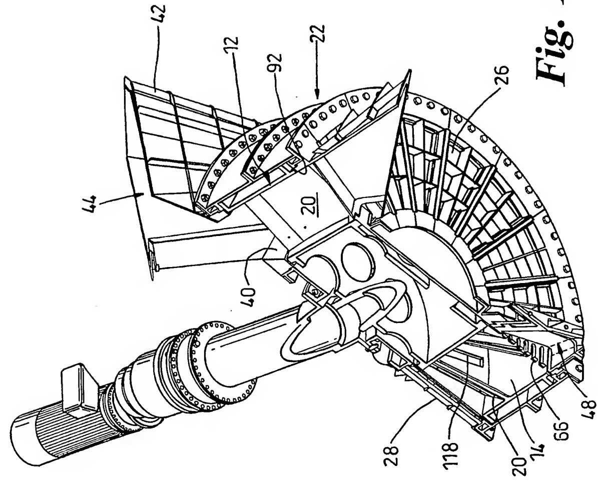

Fig. 18

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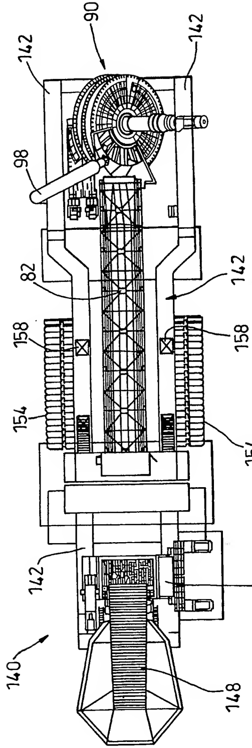

Fig. 20

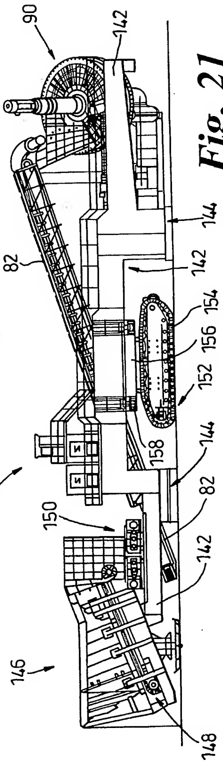

Fig. 21

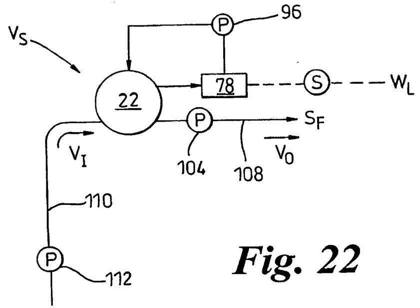
96
P
V_S
22
78
S
W_L
P
S_F
V_I
104
108
V_O
110
P
112

Fig. 22

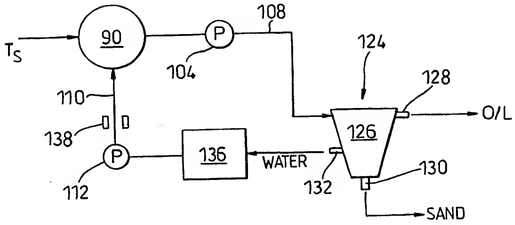
108
T_S
90
P
104
124
128
110
126
O/L
138
136
P
WATER
130
112
132
SAND

Fig. 23

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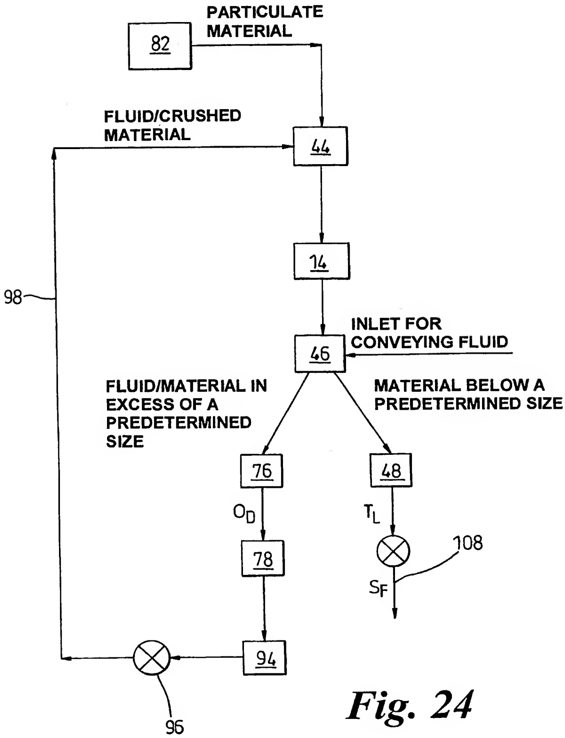
PARTICULATE MATERIAL
82
FLUID/CRUSHED MATERIAL
44
14
98
INLET FOR CONVEYING FLUID
46
FLUID/MATERIAL IN EXCESS OF A PREDETERMINED SIZE
MATERIAL BELOW A PREDETERMINED SIZE
76
48
O_D
T_L
78
108
S_F
94
96

Fig. 24

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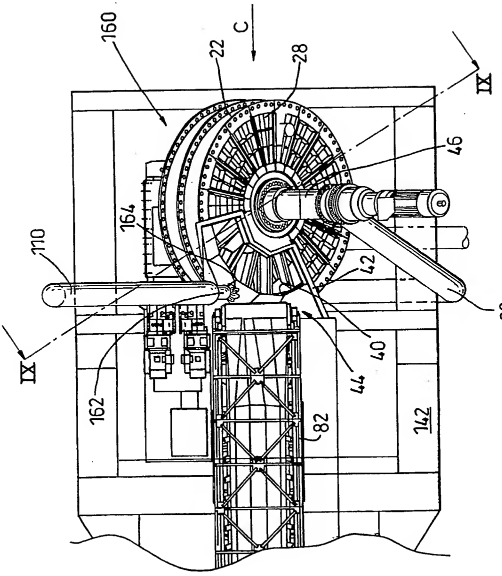

Fig. 25

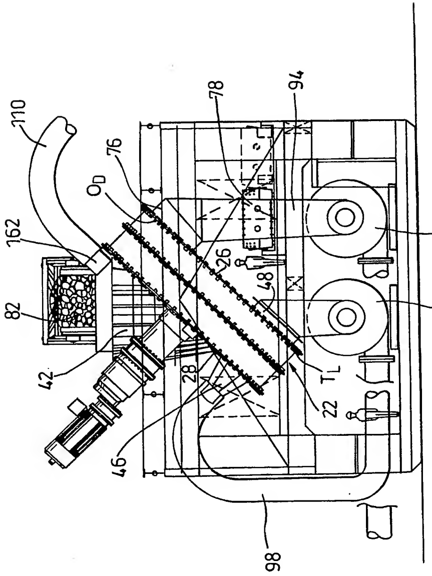

Fig. 26

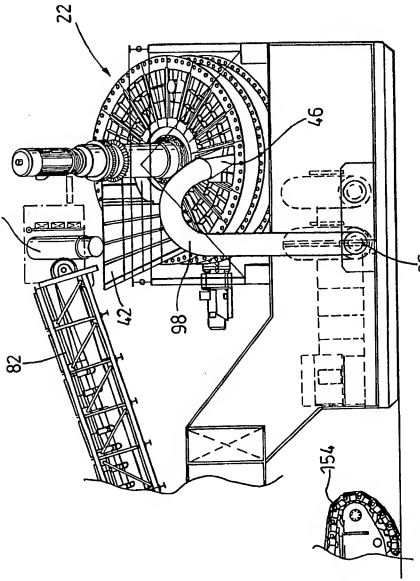

Fig. 27

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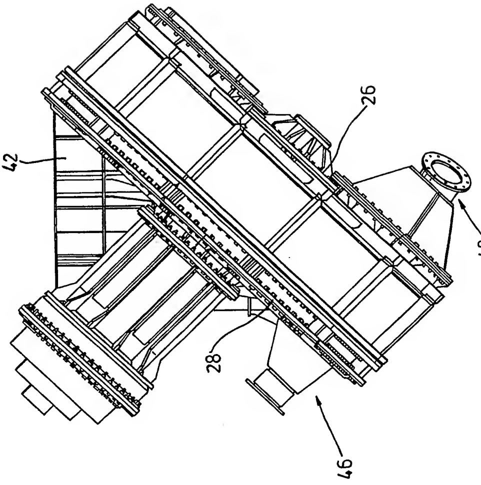

Fig. 28

SUBSTITUTE SHEET (RULE 26)

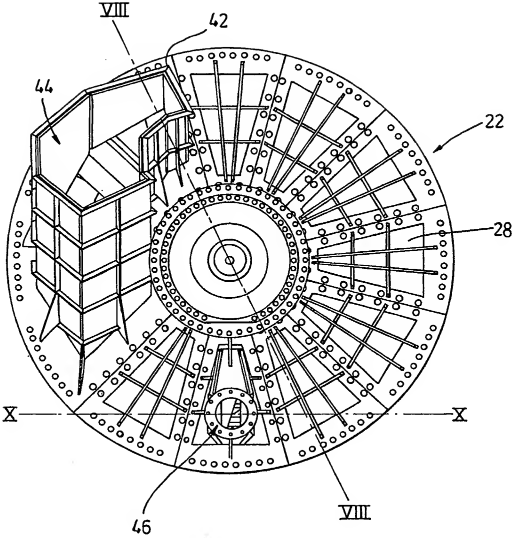

Fig. 29

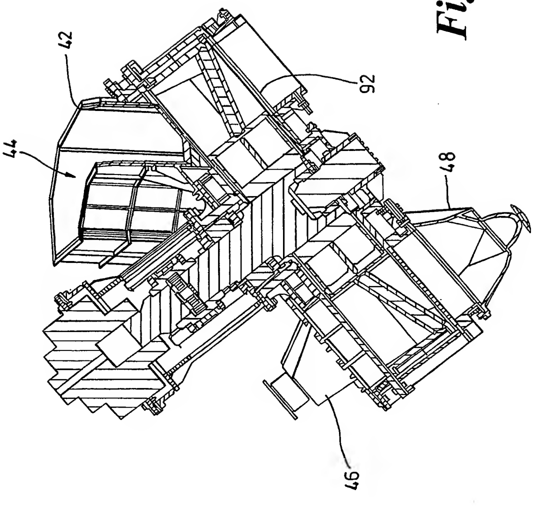

Fig. 30

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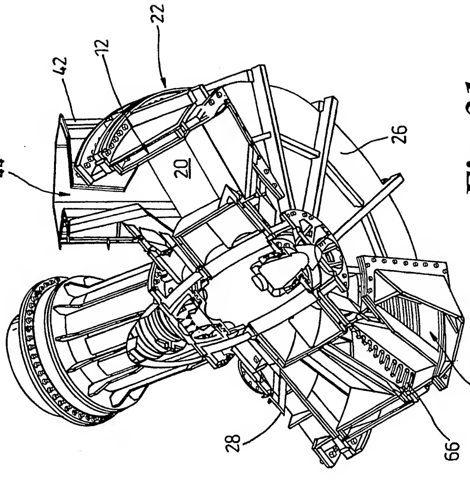

Fig. 31

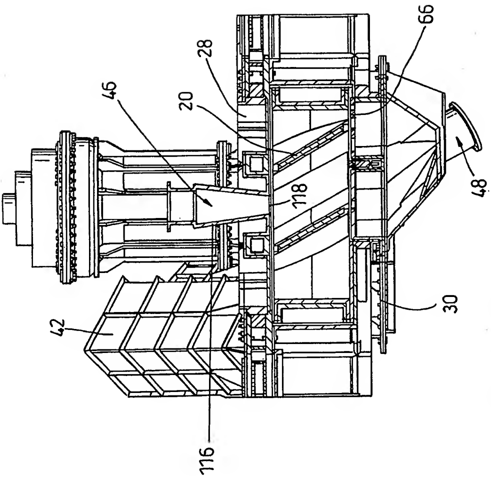

Fig. 32

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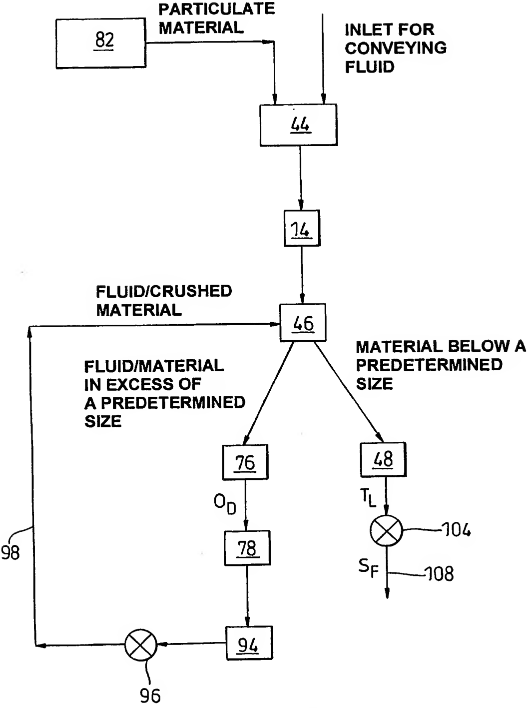
PARTICULATE MATERIAL
82
INLET FOR CONVEYING FLUID
44
14
FLUID/CRUSHED MATERIAL
46
MATERIAL BELOW A PREDETERMINED SIZE
FLUID/MATERIAL IN EXCESS OF A PREDETERMINED SIZE
76
48
O_D
T_L
104
98
78
S_F
108
94
96

Fig. 33